Chemical methods of controlling the explosion hazard during landfill gas production

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1. Introduction

Landfill gas emissions can lead to environmental and security problems in the landfill. Landfill gas migration, due to pressure differentials and diffusion, can occur. This can create an explosion hazard if the gas reaches sufficiently high concentrations in adjacent structures. Several known accidents have occurred during production. Due to the risk presented by landfill gas, there is a clear need to monitor gas produced by landfills and reduce the risks of explosion.

The investigation is devoted to elucidation of features of the action of chemically active admixtures on combustion and explosion of hydrocarbons, as well as to develop efficient methods for controlling these processes by use of selected small additives.

In order to obtain experimental evidences whether ignition at high pressures is brought by the progressive self-heating or it is due to chain branching, we have considered such features of the process, which are peculiar to only avalanche-like chain multiplication of active intermediates. We have chosen as such features the influence of minor additives (0.5-1%). In the combustion of hydrocarbons the chain branching reaction $H+O_2=OH+O$ is competing with trimolecular reaction of chain termination $H+O_2+M=HO_2+M^*$ [1-3]. M here is the third particle which offset the energy. During the combustion process part of HO_2 radicals are participating in reaction $HO_2+H_2=H_2O_2$, which, because of its high activation energy (110kJ/mol), is the limiting stage. It is clear, that by controlling the concentration of hydrogen radicals, we can control the process of combustion.

2. Technology description

The ignition and combustion of methane were studied on a hermetic cylindrical stainless steel reactor 12.6cm in diameter. Working mixtures were prepared on the basis of component partial pressures. The error in mixture compositions was 0.2% relative to the concentrations of the major components (CH_4, inhibitors and air). The initial mixture pressure and temperatures were 0.1MPa and 293K. Mixtures were ignited by a spark (mostly 3.6J). Starting from combustion initiation and to its completion pressure changes were synchronously recorded in real time.

3. Results

ΔP value (See Figure 1.) characterizes the intensity of heat release and, accordingly, the intensity of the combustion reaction.
Small admixtures of inhibitors efficiently suppress the combustion and explosion of methane-air mixtures at an initial pressure of 1 bar. The inhibition effect depends on the chemical properties of the admixture.
The difference between the effects produced by inhibitors manifests itself in all combustion parameters.

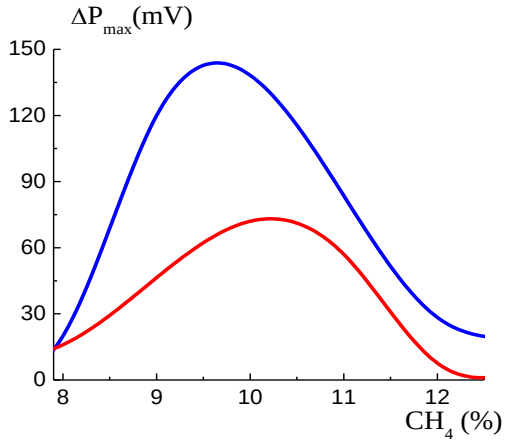

Figure 1. Dependence of maximum pressure from CH_4 concentration in mixtures with CH_4+air (blue line) and CH_4+1%In+air (red line).

Since the chain avalanche plays the determining role in combustion, the inhibition efficiency depends on both the length and the structure of inhibitor molecule. Taking into account the competition between the branching and termination of reaction chains and the correlation between the molecular structure and reactivity of the admixture makes it possible to explain and describe the observed regularities of combustion.

4. Conclusions

The regularities of flame propagation and explosion of methane are highly dependent on the molecular structure of inhibitors for given chemical composition and structure. The effectiveness of inhibitors corresponds to their ability to react with atomic hydrogen and hang a chain reaction. The competition of chain branching and termination is the determining factor in gas phase combustion. New, highly efficient and ecologically clean inhibitors were tested and suggested.

5. References

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